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DETERMINING OPTIMAL ORDERING POLICY FOR THE NAVAL OPHTHALMIC SUPPORT AND TRAINING ACTIVITY (NOSTRA)

March 2019

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ABSTRACT

This project analyzes the current inventory management practices for the Naval Ophthalmic Support and Training Activity (NOSTRA) to assess if there are industry best practices that NOSTRA could utilize to become more efficient. NOSTRA's mission is to manufacture and supply eyewear to the entire Department of Defense. The two largest inventory line items that NOSTRA carries are lenses and spectacle frames; this project specifically studies the process for managing spectacle frame inventory. An analysis of NOSTRA's current inventory management process revealed that NOSTRA utilizes a par level periodic review system. The findings of this report indicate that NOSTRA could potentially achieve efficiencies by categorizing its inventory and utilizing a 2-bin Kanban system to manage when inventory is needed and how much inventory is needed.

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LIST OF ACRONYMS AND ABBREVIATIONS

CY	calendar year
DLA	Defense Logistics Agency
DMLS	Defense Medical Logistics Standard Support
DoD	Department of Defense
DoN	Department of the Navy
ECAT	Defense Logistics Agency Electronic Catalog
EOQ	economic order quantity
FOC	Frame of Choice
GAO	Government Accountability Office / General Accounting Office
ID	identification number
JIT	just-in-time
MHS	Military Health System
NOSTRA	Naval Ophthalmic Support and Training Activity
OFE	Optical Fabrication Enterprise
RFID	radio-frequency identification
SKU	stock-keeping unit
SRTS	Spectacle Request Transmission System

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EXECUTIVE SUMMARY

The Department of Defense (DoD) could save money and become more efficient by adopting inventory practices pioneered by top civilian organizations. The focus of this project is on one DoD medical organization, the Naval Ophthalmic Support and Training Activity (NOSTRA). NOSTRA manufactures and delivers eyewear to the entire DoD. Their mission and function reside within the healthcare field, but they bear close resemblance to highly innovative sectors such as manufacturing and retail. Because of this, many best practices can be mined from those fields to enhance NOSTRA's ability to perform its mission. The purpose of this project is to observe NOSTRA's inventory management process for spectacle frames to see whether NOSTRA could benefit from any civilian organization best practices. This project specifically considers what inventory management methods fit NOSTRA the best for spectacle frames and what the optimal inventory levels are for spectacle frames.

There are two commonly used methods for managing inventory, the periodic and continuous review systems. The basic goal of a review system is to keep account of what is in inventory. This is critical as the organization depends on this system to make a host of decisions including, which supplies need to be replenished, could be used to make a finished product, or be shipped to customers. In periodic systems, inventory is monitored at discrete intervals, and in continuous systems, inventory levels are known at all times. Continuous systems are preferred but can require significant technology investments. In addition to the review systems, classification methods, such as ABC, can group inventory based on the value of inventory, demand, or other factors that management considers important. This can assist in focusing attention on items that drive the most value for an organization.

The two-bin Kanban system was popularized by manufacturing industries but has spread to other sectors such as healthcare. This system is appealing because of its ease of use and visual nature. The general idea is that stock quantities are split between two bins. Stock is initially taken from the primary bin, or the active bin. A signal for reorder is activated when the active bin is depleted. While waiting for resupply, the second bin

becomes the active bin and stock is taken from it. Once the initial empty bin is resupplied, it is placed behind the primary bin and the process continues. Safety stock is also included in each bin. This provides a protection or buffer against completely running out of stock. The amount of safety stock is based on the desired service level, which is the probability of not running out of stock.

In the case of NOSTRA, a request for eyewear begins at an Army, Navy, or Air Force medical treatment facility or ordering site. The process starts when a patient eligible for DoD care visits an optometry clinic. Once the optometrist determines eyewear is necessary, he or she measures the patient's visual acuity and prescribes the applicable eyewear. Depending on the purpose of the eyewear, the patient may be asked to choose a frame from preselected styles offered by the military optical enterprise. Optometry clinic staff enter the eyewear specifications into the Spectacle Request Transmission System (SRTS).

Demand data for this project was extracted directly from SRTS. SRTS records incoming requests for spectacles and lenses. Each request includes an order number, frame color, frame size, frame description, lens type, lens specifications (prescription information), lens material, time, and order number. The study period included 535,216 unique orders. To make a unique SKU, the frame style, size (temple type, eye and bridge size), and frame color were combined. Once all the elements were combined, 526 unique SKUs were observed. These were individual items that customers could request and that would need to be stocked or managed.

The next step was to decide as to what inventory method and order policy would be the best fit for NOSTRA. Due to technology procurement constraints, a continuous system was ruled out. Based on industry best practices, the two-bin Kanban was viewed as the best choice for inventory management. The decision was then made to categorize the frames using the ABC method. There were 48 SKUs (9%) that made up 80% of demand. The next 166 SKUs (32%) contributed the next 19% of demand. And finally, the remaining 312 SKUs (59%) made up the last 1% of demand. This distribution showed that a small portion of SKUs (9%) accounted for a disproportionately large amount of demand (80%). The group of frames that made up 80% of demand were put in category A, and the next two groups were put into category B and category C respectively. By using the ABC method, different service levels could be applied to each category of stock.

Recommendations for implementing this system include the following:

- Start with a few items. Beginning with a handful of items will allow for testing of the system in a controlled environment. Items in the upper category B or lower category A would be the best, as these are not the most critical items and would still provide enough movement through the system to properly test it.

- Decrease lead time. Lead time has a direct effect on the amount of inventory needed. Working with suppliers to reduce lead time and lead time variability will decrease the amount of inventory needed.

- Use minimal or no special software initially in implementation. One of the biggest challenges with adopting a new system within the DoD is the requirement to use new software. If a new system is dependent on new software, it could be months or years before that software is approved for use. While software exists to support the two-bin Kanban system, the system can be implemented without using that specialized software. The system recommended in this paper is designed to require low technology and is easily implemented.

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I. INTRODUCTION

A. PURPOSE

Biennially the Government Accountability Office (GAO) publishes a report listing government operations that are high-risk and vulnerable to "fraud, waste, abuse, mismanagement or that are in need of transformation to address economy, efficiency, or effectiveness challenges" (Government Accountability Office [GAO], 2017, p. 1). The GAO identified the Department of Defense (DoD) supply chain as a high-risk area. Specifically, the GAO identified materiel distribution and asset visibility as areas that needed the most improvement within the DoD's supply chain. This is not a new concern, particularly for medical inventory management. A GAO report completed in 1991 specifically compared military medicine's inventory practices to the leading civilian hospitals to identify practices the DoD could adopt (GAO, 1991). This report found that the DoD could save millions of dollars by adopting inventory practices pioneered by top civilian hospitals. Since the report was published, the DoD has put some of the best practices in place. Nevertheless, civilian inventory management practices have continued to evolve, and the DoD should continually seek those best practices that can enhance their operations.

The focus of this project is on one DoD medical organization, the Naval Ophthalmic Support and Training Activity (NOSTRA). NOSTRA manufactures and delivers eyewear to the entire DoD. Their mission and function reside within the healthcare field, but they bear close resemblance to highly innovative sectors such as manufacturing and retail. These sectors can contribute best practices to enhance NOSTRA's ability to perform its mission. The purpose of this project is to explore NOSTRA's inventory management system and suggest inventory best practices that NOSTRA can utilize.

B. BACKGROUND

Before World War II, U.S. military physical standards precluded candidates with reduced visual acuity from enlisting or commissioning (NOSTRA, n.d.). After the bombing of Pearl Harbor, visual standards were lowered to meet the escalating demand for military members, according to the history section on NOSTRA's website. The Navy initially contracted with civilian laboratories to meet the rapidly growing demand for ophthalmic services. However, demand soon exceeded the capacity of civilian services, and the first U.S. military ophthalmic program to provide prescription eyewear to Navy and Marine Corps personnel serving abroad was enacted with the Navy Appropriation Act of 1942. By, 1945 a program was established to offer prescription eyewear to all Navy personnel. According to NOSTRA (n.d.), this program required more trained personnel, and in June 1945, an Optical School at the U.S. Naval Medical Supply Depot was established in Brooklyn, New York. The school was later relocated to the Naval Medical School, National Naval Medical Center, Bethesda, Maryland, and renamed the Optometric Fabrication School. While the school was moved to Maryland, the optical fabrication laboratory was relocated to the Naval Supply Center Cheatham Annex, Williamsburg, Virginia, and re-designated the Naval Ophthalmic Lens Laboratory. Eventually the optician training program was rejoined to the laboratory, and the activity was designated with command status as Naval Ophthalmic Support Activity (NOSTRA) at its current location of Naval Weapons Station Yorktown, Virginia (NOSTRA, n.d.).

In 1999, the DoD began to provide eyewear for approved DoD beneficiaries, and the Tri-Service Surgeons General established the Optical Fabrication Enterprise (OFE). The Navy was designated the lead service for optical fabrication, and the Navy surgeon general selected the commanding officer of NOSTRA as the program executor (Department of the Navy [DoN], 2015). The categories of frames that NOSTRA primarily delivers are standard issue, frame of choice, aviation frames, protective eyewear, protective mask inserts, and laser eye protection prescription devices. NOSTRA also has capabilities to produce multifocal lenses (e.g., bifocals or trifocals), add lens tinting and lens coating (e.g., coating to produce anti-reflective lenses), and produce specialty lenses. The focus of this project, however, is on NOSTRA's frames.

Service members in the military training pipeline are initially supplied with standard issue frames. These sturdy frames are also available to other beneficiaries. Once out of the training pipeline, eligible beneficiaries have access to a collection of civilian-style frames, through a program called Frame of Choice (FOC). The OFE is the administrator for the program and constantly evaluates cost, demand, and trends. The OFE also leads the board that tests potential frames for suitability and potential demand.

C. OBJECTIVE

The principal objective of this project is to observe NOSTRA's inventory management process for frames to see whether NOSTRA could benefit from any civilian organization best practices. This would give NOSTRA tools to consider that could ultimately make its inventory management operation more efficient. Inventory management operations are central to NOSTRA's mission, and any efficiencies achieved will ultimately help improve customer service and satisfaction. NOSTRA has reported that, for some line items, it has too much inventory and for others too little. This project will assist NOSTRA in developing the optimum inventory strategy to address those issues.

The emphasis of this research is to find the best practices in inventory management and highlight any that would potentially fit NOSTRA's business model. Methods that are adaptable in the near future will be prioritized over those that are far out of the reach of the organization due to technological, financial, or cultural reasons. Considering the above goal, the primary research questions are as follows:

1. What inventory management methods fit NOSTRA the best for spectacle frames?

2. What are the optimal inventory levels for spectacle frames?

D. SUMMARY

This chapter began by discussing the reason this project was selected and its importance to the DoD. Next it briefly reviewed NOSTRA's history and the purpose it serves. Then this chapter discussed the objectives of this project and the research questions that will be answered.

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II. LITERATURE REVIEW

There is little literature that specifically studies the inventory management practices of optical laboratories. However, because the products that optical labs carry have an extremely long shelf life and generally do not require special storage, the literature covering general inventory management practices across industries such as healthcare, manufacturing, and retail is applicable. In this section, we discuss inventory review methods, ordering policies, service levels, classification methods, and the Kanban system.

There are two commonly used methods for managing inventory, the periodic and continuous review systems. The basic goal of a review system is to keep account of what is in inventory. This is critical as the organization depends on this information to make decisions on what supplies need to be replenished, can be used to make a finished product, or be shipped to a customer.

A. PERIODIC REVIEW SYSTEM

Under the periodic review system, inventory levels are monitored at discrete intervals. An example of a periodic review policy would be to check inventory levels once a week. If the quantity is below a pre-set level, an order is placed to bring the inventory up to the desired stock level (Olson, 2014). This inventory method is easy to implement and was popular before the advent of computers. Because inventory is monitored only at discrete intervals, as compared to the continuous review system, the risk of a stock out (i.e., inventory is completely depleted) is greater in a periodic review system, requiring a larger amount of safety stock.

B. CONTINUOUS REVIEW SYSTEM

With a continuous review system, the level of stock is monitored at all times (Olson, 2014). This system uses computers to track when stock is distributed and also when it is replenished, thereby giving the user real-time inventory levels. Often a continuous review system can be set up to automatically order stock when the level falls below a predetermined level. Because the continuous system tracks when items are stocked and dispensed, the system that manages this process can provide a lot of data, such as demand, age of inventory, or seasonality (Galka, 2016). This system is often viewed as the most optimal, as it gives a continuous view of inventory and can provide data about the supply chain. These advantages can lead to further optimization and also require a smaller amount of safety stock. However, this system may not always be practical, as it requires investing in technology and updating processes to support the system.

C. ECONOMIC ORDER QUANTITY

Economic order quantity (EOQ) can best be described as a decision rule that indicates "what quantities one must order items in, so as to minimize the cost associated with them" (Roach, 2005). This approach balances the cost of ordering an item (or lot of items) against the cost of carrying that item in inventory. The primary assumptions when using EOQ are that demand is continuous and constant, the process continues indefinitely, and that there are not quantity constraints on order quantity or storage capacity (Roach, 2005). The equation used to determine EOQ follows (Silver, Pyke, & Peterson, 1998, p. 32).

$$\text{EOQ} = \sqrt{\frac{2DK}{h}}$$

where

D = item annual demand
K = ordering cost
h = holding cost

Ordering cost is not the cost of the item but is the cost of deciding replenishment needs, processing purchases, and receiving incoming orders. Holding cost can include the cost to store goods, the opportunity cost of having funds tied up in inventory, inventory losses, and even obsolescence cost (i.e., expenses related to an item becoming obsolete; GAO, 1993).

The EOQ model was first presented by Ford Whitman Harris in a paper published in 1913. That initial paper went largely unnoticed before it was rediscovered in 1988 (Erlenkotter, 1990). As far back as 1988, the GAO identified several problems associated with the DoD's use of the EOQ model (GAO, 1993). One problem is that ordering and holding cost must be accurate, and often maintaining that accuracy requires periodic updates. For example, the GAO report noted that the wrong discount rate was used in DoD cost–benefit studies to estimate holding cost. Another issue is that EOQ assumes constant demand, and that is not always true. These assumptions are significant, as private sector companies interviewed by the GAO considered EOQ outdated and unattractive due to its assumptions (GAO, 1993). These companies have adopted strategies that minimize inventory carried to only what is immediately needed.

D. SERVICE LEVEL

Service level can be defined as “the expected probability of not hitting a stock-out during the next replenishment cycle” (Rădăşanu, 2016, p. 146). A stock out is when inventory is completely exhausted before replenishment occurs. The level of stock an organization holds determines the service level (Rădăşanu, 2016). Safety stock (SS) is the protection factor that covers an organization during delivery times, demand fluctuations, and other unknown variables that may cause a stock out (Rădăşanu, 2016). Figure 1 shows this process graphically.

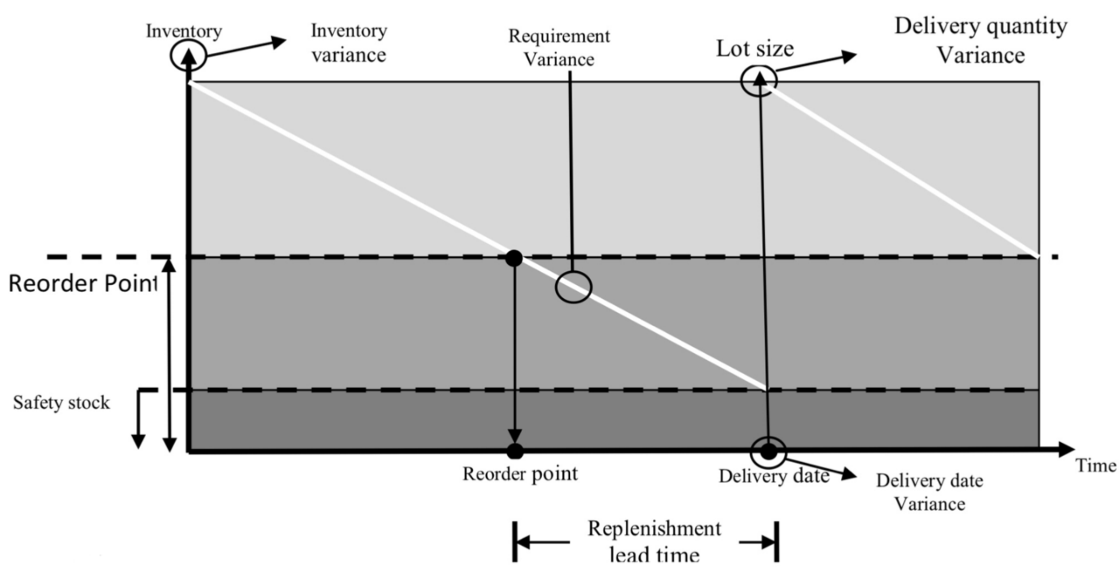

Figure 1. Reason for Safety Stock. Source: Rădăşanu (2016).

Choosing a service level is a balancing act. There may be sufficient justification to have an extremely high service level due to importance of the client or products. The trade-off with high service levels is high inventory levels, which also carries a cost. A standard formula for calculating safety stock when demand and lead time variability are both known and independent of each other is as follows (Sandvig, 1998):

$$\text{safety stock} = Z * \sigma_D * \sqrt{L}$$

where
Z = Z-score consistent with the desired service level
σ_D = standard deviation of daily demand
L = lead time (days)

E. ABC INVENTORY MANAGEMENT

With the ABC Inventory Management method, organizations can classify their inventory using a variety of methods. The methods range from utilizing dollar value to employing optimization equations or artificial intelligence that considers multiple criteria. However, subjective weighting schemes can be just as useful, and at times more so, than more analytical intensive methods (Ravinder & Misra, 2014). Using subjective weighting, managers can easily change the weighting as management priorities change. Also, this method is not dependent on new managers or staff understanding optimization equations, which can require extensive training to use or update.

One of the primary inventory classification methods is the ABC Inventory management system, which groups inventory into three categories. Items in category A get the most attention, C items get the least attention, and B items are in-between (Ravinder & Misra, 2014). This method is based on the law of Pareto, which states that "in many projects 20% of the total effort yields 80% of the total outcome" (Ultsch, 2002, p. 1). Many organizations have thousands of stock-keeping units (SKUs), and it may not be practical to manage all of them with the same level of intensity. SKU "will be defined as an item of stock that is completely specified as to function, style, size, color, and usually, location" (Silver et al., 1998, p. 32).

Once inventory has been classified, it can generally be expected that category A items represent roughly 15%–20% of overall inventory, but account for 80% of the value. Inventory in category B will likely represent 30%–35% of overall inventory and account for 15% of the value, while inventory in category C will represent the approximately remaining 50% of inventory, but only account for around 5% of the value (Rusanescu, 2014). This classification approach can be used to differentiate the level of stock control each group is given. Stock in category A may require detailed record keeping and constant monitoring, while C items may be managed more loosely. Also, while it may not be practical to utilize a continuous review system for the entire inventory, category A items could be managed in a manner that approaches a continuous method (while likely still being discrete).

Using ABC analysis, organizations can set different service levels for each category. For example, category A items classified as critical can be given a high service level (e.g., 95–99%), category B items given a service level of 90–95%, and category C items 85–89%. There are more sophisticated methods of determining service level for individual products, however, and we discuss one such system next.

F. TWO-BIN KANBAN AND JUST-IN-TIME

The Kanban system originated in Japan as a part of the Toyota Lean Production System. In Japanese, the word *Kan* means "visual" and *ban* means "card"; therefore, *Kanban* literally means visual cards. This method uses visual cards as a signaling system that generates an action to supply the process with its needs either from an external supplier or from a warehouse (Sabry, 2010). In the late 1940s, Toyota realized an effective engineering process from an unlikely source, the American supermarket. They realized that the store clerks restocked grocery items by their store's inventory. The clerks only placed an order when an item was almost sold out. The grocers' "just-in-time" delivery process sparked Toyota engineers to reconsider their methodology and develop a new approach that would match inventory with demand and achieve higher levels of quality and throughput. The foundation of Toyota's innovation was a stockless inventory system; see Figure 2 for a visual representation of how Toyota uses the Kanban system. A stockless inventory system is achieved by the just-in-time (JIT) philosophy. The objective of JIT is to remove waste from the manufacturing environment in order to produce the right quantity of products at the highest quality at the right time (Silver et al., 1998). Waste is defined as anything that prevents the organization from attaining those goals (e.g., inventory or disruptions). While JIT encompasses a firm's entire manufacturing process, and even management philosophy, Kanban is a system within JIT to control workflow and inventory.

The Kanban system has become popular in industries outside of manufacturing, such as healthcare. A *New York Times* article described how hospitals have improved care and lowered cost by using innovations such as the two-bin Kanban system (Weed, 2010). This system allowed Seattle Children's Hospital to decrease its storeroom by half and discard fewer supplies due to expiration. Historically, healthcare organizations have relied on other types of periodic review methods such as the requisition system, exchange carts, and the par level (Landry & Beaulieu, 2010). The requisition system requires nursing staff to conduct regular inventory counts and consumption estimates. When medical supplies are low in inventory, a requisition is sent to the materiel management department to be picked out of central supply. Nursing staff are often required to put away the products as well. With the exchange cart system, medical supplies are stocked in a cart that is placed on the hospital ward. Once the cart is completely empty, it is exchanged for a fully stocked cart in materiel management, and the depleted cart is then restocked. Multiple SKUs are usually placed in the same cart in this method. Depleting supplies at different rates could cause problems with stock outs or keeping excess inventory. In the par level system, the ward supply room is inventoried on a predetermined schedule. Quantities of each supply item are entered into an inventory management system. The quantity on the shelf is then compared to the establish level each item should have. If the level in the store room is less than the established level, an order is placed, and the items are delivered to the supply room.

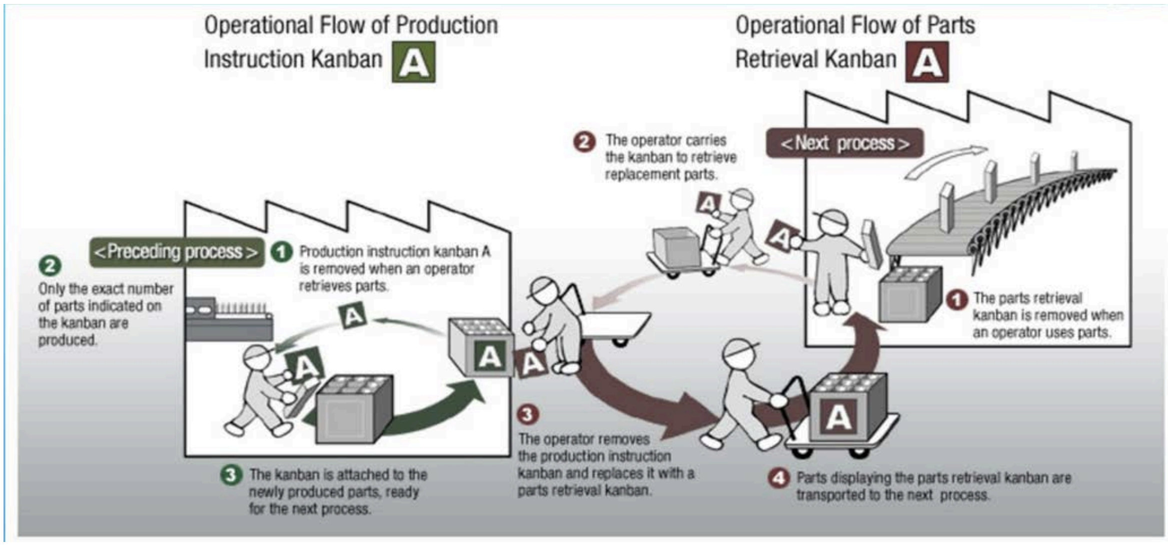

Figure 2. Conceptual Diagram of Kanban System. Source: Toyota (n.d.).

In comparing these systems, Landry and Beaulieu (2010) ranked the inventory methods across three dimensions: contact between storekeepers and nursing personnel, degree of nursing personnel participation, and average amount of inventory that the system had to maintain, with the goal to minimize each dimension. The study found that the two-bin Kanban system tended to perform better across all the dimensions. In the two-bin system, staff simply had to place an empty bin, or a magnet in the case of a radio-frequency identification (RFID) system, in a designated place to signal a need for re-order. Also, the system removed the time-consuming and error-prone task of counting stock. In the two-bin system, an order is placed for the entire bin quantity once it is emptied. Finally, the two-bin system was generally implemented with a modular storage system. Modular storage systems generally take up less space than conventional storage units; therefore, organizations are able to store the right amount of stock in generally less space than using conventional storage methods.

In practice, the two-bin Kanban system is meant to be simple and visually easy to understand. It can be utilized with advanced technologies such as RFID or simply with colored coded cards. The general idea is that stock quantities are split between two bins, or one bin split into two sections. Stock is initially taken from the primary bin, or the active bin. A signal for reorder is activated when the active bin is depleted. While waiting for resupply, the second bin becomes the active bin, and stock is taken from it. Once the initial empty bin is resupplied, it is placed behind the primary bin and the process continues (Landry & Philippe, 2004; Olson, 2014). This process is shown graphically in Figure 3.

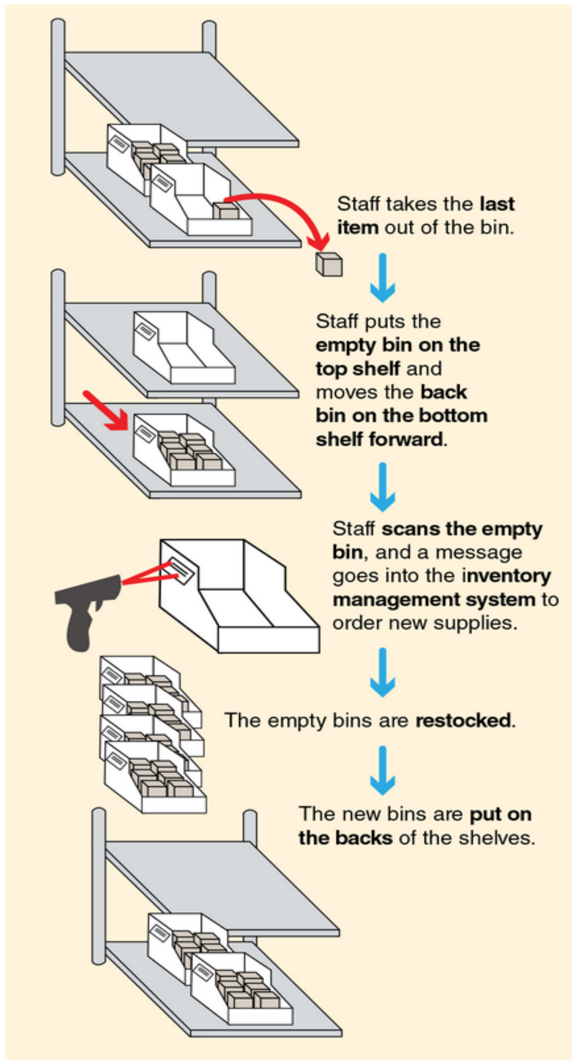

Figure 3. Two-Bin Kanban System. Source: "Hospital Supply" (2018).

In the presence of significant and measurable ordering cost, how much to reorder is often calculated using the EOQ equation. This is a well-known equation among many supply managers because it considers various factors that may be important to management, such as inventory carrying and ordering cost. However, as mentioned above, there are reasons that organizations would want to utilize alternative ordering formulas, especially when the order cost is very low or insignificant. Because one of the goals of the two-bin Kanban system is to decrease inventory, simply ordering what you need when you need could also be an option. When taking in consideration daily demand and lead time, purchasers can place orders at regular intervals for the quantity needed. This method decreases amount of inventory on hand. The alternate equation for calculating two-bin Kanban order quantity is as derived by Professor Uday Apte (personal communication, October 28, 2018).

$$\text{order quantity} = (L * DD) + SS$$

where,
L = average lead time (days)
DD = average daily demand
SS = safety stock

Using the above formula, each bin would contain an amount equal to order quantity. Once the first bin has been completely exhausted, material from the second bin is placed into use. Therefore, bin 2 must have an amount sufficient to continue operation and contain safety stock sufficient to protect against stock out during the lead-time at the chosen service level; here, the size of bin 2 would be the order quantity, (L * DD) + SS. When bin 1 is replenished, it is placed behind bin 2 until bin 2 is completely exhausted (hence, the size of bin 1 = the size of bin 2) and the process continues.

G. CHANGE MANAGEMENT

Because this project could potentially involve major changes in the organization’s inventory management policies, this section presents a brief discussion of important considerations in this area. Research on change management is very useful in showing where to focus energy in any major process modification. Projects of this sort can be broken down into three phases: preparation, execution, and consolidation. The preparation phase is often viewed as the most important phase as it gives the foundation for the entire project (Fritzenschaft, 2014). It is usually in this phase that the biggest mistakes are made and the risk of failure is the largest. Within the planning phase, the factors that have been shown to be the most important for success are defining the objectives, communicating the vision, and creating a shared awareness of the problem. Therefore, starting with why the change is important to the organization, how the current system impacts all staff, and finally how an improved system will positively affect the organization's mission and the staff that carry out that mission are the most important factors in the implantation. Important factors in the execution phase include determining competence and responsibilities, involving staff, providing appropriate resources, and using a systematic approach. Finally, in the consolidation phase, communicating results and continuously monitoring progress are important to cement the results.

H. SUMMARY

First, this chapter presented a review of the differences between periodic and continuous review systems. Next, the economic order policy was examined along with its pros and cons. Then service level was defined along with the rationale for carrying safety stock. After that the ABC inventory classification method was discussed along with a brief overview of how it is applied. Then, the two-bin Kanban and just-in-time inventory systems were reviewed. Finally, the chapter briefly reviewed considerations when conducting a major change within an organization.

III. PROCESS AND METHODOLOGY

A. PROCESS

As the lead service for optical fabrication, NOSTRA fabricates and ships eyewear to military members from all services. A request for eyewear begins at an Army, Navy, or Air Force medical treatment facility or ordering site and is governed by a joint DoD instruction that specifies responsibilities (DoN, 2015). The process starts when a patient eligible for DoD care visits an optometry clinic. Once the optometrist determines eyewear is necessary, he or she measures the patient's visual acuity and prescribes the applicable eyewear. Determining eligibility is the responsibility of the optometry clinic. They also must assign a priority code for the eyewear request, according to Table 1 below. Priority codes 1 through 5 are considered urgent and generally should be processed within 24 hours of being received by a lab. Priority codes 6 and 7 are considered routine and are sent out "as soon as possible" (DoN, 2015). Patients not in a training pipeline or who need specific eyewear (e.g., pilots or gasmask inserts) choose frames from the FOC program. Currently there are 10 frame styles in the FOC program (Naval Ophthalmic Support and Training Activity, n.d). NOSTRA disseminates information about available frame styles, colors, and sizes to DoD optometry clinics via its website. Optometry clinic staff enter the eyewear specifications into the Spectacle Request Transmission System (SRTS). SRTS is a Tri-Service web-based application that allows authorized optical clinics "worldwide to record, store, retrieve, and transmit spectacle request information to optical fabrication labs as needed" (DoD, n.d.). Ordering sites must input orders into SRTS within one business day. While NOSTRA is the lead agent for optical fabrication within the DoD, they are not the only DoD optical laboratory. Ordering sites have the latitude to choose from among all DoD optical labs for eyewear fabrication; only certain labs, however, have capabilities to produce very specialized orders, and NOSTRA is one of two DoD labs that have specialized capabilities. Because of this, there is competition among optical laboratories for spectacle orders, which can affect demand.

Once an order is input into SRTS and is received by NOSTRA, it is sorted and prioritized based on the prioritization system in Table 1 by an optometry technician. The technicians also decide where the order needs to go in the facility. There are two primary parts of the optical lab at NOSTRA, the finish side and the surface side. The finish side contains common lens prescriptions that can be used without any further modifications and only need to be cut to fit the required frame, also known as off-the-shelf lenses.

Table 1. Spectacle Priority System. Source: DoN (2015).

Priority Code 1	Readiness: Orders for those deploying within 30 days of the order.
Priority Code 2	Downed Pilot: A pilot who has a significant change in vision that will, without spectacles, result in immediate grounding and degrade combat readiness and effectiveness of the unit to which assigned.
Priority Code 3	Trainee: Spectacles and insert orders for personnel undergoing basic, ROTC, or Academy training.
Priority Code 4	Wounded Warrior: Used for eligible wounded personnel suffering from TBI.
Priority Code 5	Very important persons: Used for ranks O-7 and above.
Priority Code 6	Standard Issue: Standard issue frames that are not for an above reason.
Priority Code 7	Frame of Choice: Frame of Choice orders that are not for Wounded Warriors or Active Duty VIPs.

The surface side contains raw lenses that need to be ground down to the correct prescription curve and then cut to fit the frame. At NOSTRA, approximately 60% of orders are fulfilled by the finish side, while 40% of the orders are fulfilled by the surface side (J. A. Kent, personal communication, May 18, 2018). Orders that come to NOSTRA contain visual acuity measurements that technicians use to decide whether they should go to the finish or surface side and then which lens product should be used on the respective side. Orders that should go to the surface side cannot be filled by the finish side, or vice versa. After the order is received, the visual acuity information is then transcribed onto a form, placed in a tray, and sent to the appropriate part of the lab for processing. The next step is for the frame and lens product to be added to the tray. This is accomplished by a technician who walks the tray to the frame and lens inventory sections to add the appropriate one from each. Frames are kept in one location in the facility, while off-the-shelf lenses are kept on the finish side and raw lenses on the surface side. A layout of NOSTRA's processing facility is shown in Figure 4.

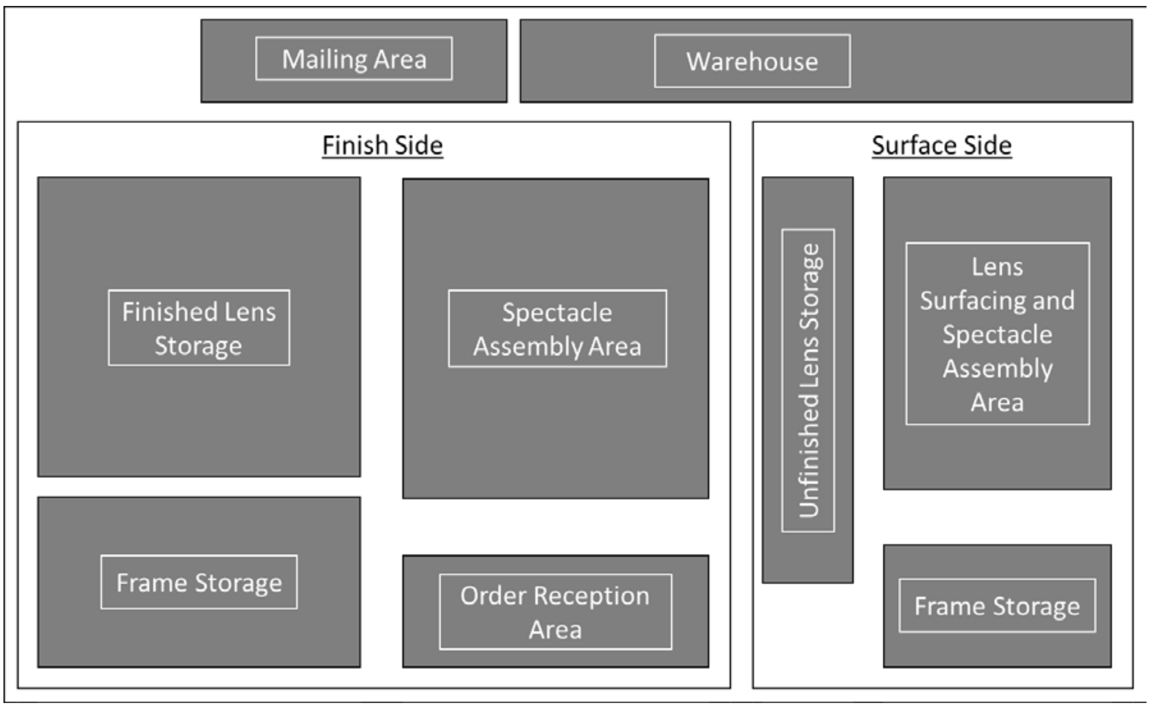

Figure 4. Layout of NOSTRA's Spectacle Processing Facility

Photographs of the lens storage can be seen in Figure 5 and Figure 6. If there is a stock out of either lenses or frames, the tray is put aside and an order is placed for the item. After the correct lens and frame are added to the tray, it is placed on the production line. On the production line, the lenses are ground to the correct prescription dimensions, if needed, cut to fit the frame, polished, mounted to the frame, and finally reviewed by a quality assurance technician. The process after NOSTRA receives an order is detailed in Figure 7.

Note. Photo taken by LT Ramon Gavan on May 18, 2018, at NOSTRA.

Figure 5. Nostra Shelving for Frames

Note. Photo taken by LCDR Jonathan Fowler on May 18, 2018 at NOSTRA.

Figure 6. NOSTRA Shelving for Lenses

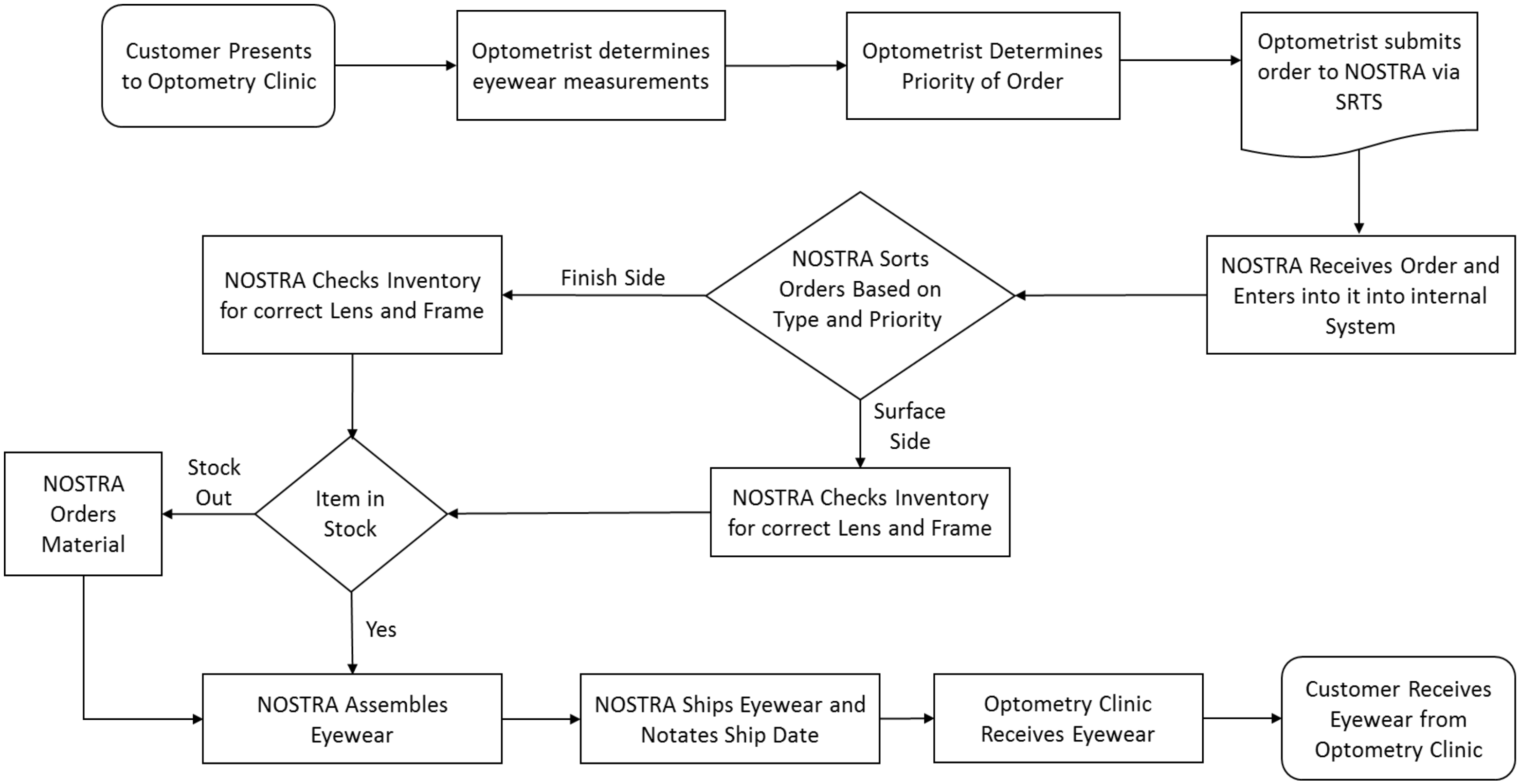

Figure 7. NOSTRA's Process Chart

NOSTRA currently utilizes the par level system, a subset of the periodic review system for some items, and a continuous review system for others. Inventory is primarily stored in two locations, in the manufacturing area and also in a warehouse storage area. Items in the manufacturing area are managed using the par level system. Each inventory bin in the manufacturing area has a barcode associated with it. At least weekly, a supply technician scans the barcodes and notes how many items are in the bin. A level is set for each SKU based on usage and lead-times. If the number of items in the bin is less than the level set in the inventory management system, a replenishment request is created. There is no standard formula used for re-order points or amounts held. An example of a replenishment decision is, once the bin reaches five items, 10 items are ordered. The warehouse is primarily used to store additional quantities of high usage items. They are managed using a continuous review system with an inventory management software system. When items are removed or added to the warehouse, a notation is immediately made in the system. Supply personnel have the capability to run reports to distinguish between high and low usage items, dead stock, and have to make decisions about which low usage items should be carried.

B. DESCRIPTION OF DATA SOURCE

NOSTRA utilizes the Defense Medical Logistics Standard Support (DMLSS) management information system and the Spectacle Request Transmission System (SRTS) as decision support tools to manage supply, demand, and equipment. DMLSS contains modules to manage medical materiel, equipment, facilities, and war reserve materiel (Military Health System [MHS], n.d.). NOSTRA utilizes DMLSS to manage the ordering process for spectacles and lenses, among other items. DMLSS can be used to track quantity of stock on hand, ordering history, and par levels (i.e., the minimum quantity of inventory that must be kept on hand). Data extracted from DMLSS for this project included a description of the items ordered, item identification number (ID), where the item was ordered from, quantity of items ordered, price, and a unique ID number that DMLSS assigns to each order. This dataset included all items ordered during calendar year (CY) 2017. Currently SRTS and DMLSS are completely separate systems and do not communicate directly. Due to this, resupply decisions must be made manually. DMLSS can suggest par levels, but these must be scrutinized and are often adjusted manually because the DMLSS cannot see demand data. Because incoming orders via SRTS cannot be directly traced to a decision to re-supply items via DMLSS, we used the DMLSS dataset only to observe the source of supply.

NOSTRA also manually tracks when orders are shipped. This data is input in a spreadsheet and includes information such as a description of the lens and frame utilized, origination of order (e.g., SRTS or direct request from higher headquarters for humanitarian mission), and date order was shipped. This dataset does not include any data field that would allow it to be linked to the SRTS data set. For that reason, we also excluded this shipment data from the analysis.

Demand data for this project was extracted directly from SRTS. SRTS records incoming request for spectacles and lenses. Each request includes an order number, frame color, frame size, frame description, lens type, lens specifications (prescription information), lens material, time and order number. Incoming requests also include information on where the order came from, where it should be sent, and possibly other personally identifiable information, but that information was not requested or included in the dataset utilized. Data from SRTS was used to understand the demand for types of frames and how that demand was distributed over time. The time period observed was CY2017.

When requests for spectacles enter SRTS, they contain clinical specifications that must then be translated into a lens product. This is usually done based on the knowledge of optometry technicians and is not a straightforward task for individuals untrained in the optometry field. Therefore, this project focuses on frame orders, which do not require such expertise. Frames orders submitted to NOSTRA contain size information. Frame sizes are made up of three numbers, lens diameter, bridge size, and side length (see Figure 8). These measurements are usually computed in millimeters. Frames are similar to retail clothing in that they are not usually custom built but have standard sizes and patients are assigned a size that most closely fit them.

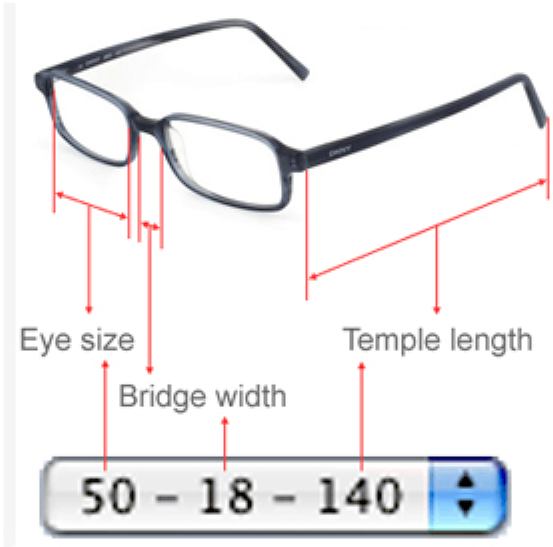

Figure 8. Eyeglass Frame Measurements. Source: EyeGoodies (n.d.).

Examples of the SRTS output data can be found in Tables 2 and 3. It should be noted that the data on frame requests did not include a date stamp, while data on lens requests did. Because a unique order number is generated for each incoming order in SRTS and that number is associated with a lens and frame specification, frame orders were able to be matched to lens orders in order to add the date the order was received for frames.

Table 2. Example of Data Set from SRTS System for Lens Orders

Order Number	OD Sphere	OS Sphere	OD Cylinder	OS Cylinder	OD Add	OS Add	Lens Type	Multifocal Type	Lens Material	Tint	Date Received
0099000006956-17	-5.75	-5.25	-0.75	-1	0	0	SV		HI	CL	12/15/17 3:19
0099000006958-17	-5.75	-5.25	-0.75	-1	0	0	SV		PLAS	CL	12/15/17 3:24
0010080001178-17	0.5	-1.25	-0.75	-1	2.25	2.25	MV	Bifocal, Standard	PLAS	CL	2/7/17 9:12
0010392090057-17	0.75	0.75	-0.75	-0.75	2.25	2.25	MV	Trifocal, Standard	PLAS	CL	2/10/17 7:33
0010300002872-17	0.25	0.5	-0.75	-1.25	0	0	SV		PLAS	UV	7/14/17 14:02

Note. The above table contains clinical information from the optometrist concerning lens specifications. This information is then translated into a lens product by a trained optometry technician at NOSTRA. Each order number is for one unique product requested by a clinic.

Table 3. Example of Data Set from SRTS for Frame Orders

Order Number	Frame Style	Frame Color	Frame Eye Size	Frame Bridge Size	Frame Temple Type
0000010000498-17	5A LARGE STANDARD FRAME	BLK	52	18	145SKL
0000010000411-17	AIR FORCE FLIGHT FRAME	GLD	55	18	145SKL
0001242091388-17	ELLSWORTH	GMO	53	18	145SKL
0000340002812-17	KEESLER	BBR	55	15	140SKL
0000900001001-17	M-45 INSERT	CRS	38	30	NONE

Note. An example of data for frame orders from SRTS is given above. There is a unique order number generated for each frame and corresponding lens. Frame style, color, eye size, bridge size, and temple type were combined to yield a distinct SKU that must be carried by NOSTRA.

The study period included 535,216 unique orders, and these orders were pulled from only 41 frame styles. The major categories of frame types were standard frames issued to trainees, frames for pilots, and frames in the FOC program. To make a unique SKU, the frame style, size (temple type, eye size, and bridge size), and frame color were combined, as shown in Table 3. Other characteristics of a SKU, such as function and location, were not relevant to this project. Once all the elements were combined, 526 unique SKUs were observed. These were individual items that customers could request and that would need to be stocked or managed through a just-in-time inventory program.

C. SUMMARY

This chapter began with a description of the process customers go through to receive glasses via NOSTRA, including the priority system for customer requests. Then NOSTRA's current inventory management process was reviewed. Next the chapter reviewed the data sources, the inventory management data systems NOSTRA uses, including their limitations and how they were utilized in this project. Finally, this chapter concluded with an example of how frames are measured, example data output from SRTS, and an example of how unique SKUs were.

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IV. ANALYSIS AND RESULTS

A. ANALYSIS

The frame data that was extracted from the SRTS system was first paired with lens data of the same system to match order numbers and dates the orders were received. Then frame style, color, eye size, bridge size, and temple type were combined to yield a distinct SKU. Finally, orders were aggregated to view demand of each SKU by day, week, month, and total for calendar year. Table 4 below gives a snapshot of the aggregate demand by month and total for calendar year, ranked in descending order of demand.

Once demand data could be easily viewed, a decision was made as to what inventory method and order policy would be the best fit for NOSTRA. First a decision was made between a continuous or periodic ordering system. While a continuous system would be theoretically possible for NOSTRA, this system was viewed as impractical in the short term. It would require increased bar-code scanning capabilities and other technology that NOSTRA does not currently possess. Also, in the DoD, procuring new software or hardware systems can be a lengthy process; along with the timeline associated with securing funding and ordering the new system(s), the new system(s) must be vetted before being integrated with already approved technology systems. Therefore, the decision was made to utilize a periodic review system. Currently NOSTRA uses a par level periodic review system. This requires weekly and possibly daily checks of inventory to monitor levels of stock. Consistent with current literature, a two-bin Kanban would likely prove to be a more efficient system. This method would rely on easy visual cues, such as if a bin is empty, thus relieving the need to conduct periodic inventory checks. Also, NOSTRA operates in both the healthcare and manufacturing sectors. The two-bin Kanban was invented by and has revolutionized the manufacturing sector, while it has relatively recently been adopted by the healthcare sector as a best practice in inventory management.

Next, a decision was made as to ordering policy. Two ordering policies were covered in the literature review, EOQ and simply ordering based on lead-time and demand. The EOQ model seeks to find the optimum ordering quantity to balance ordering and carrying costs. As discussed in the literature review, accurately quantifying carrying cost could be a significant project for NOSTRA. They do not rent or lease space and there are no immediate monetary incentives for carrying less inventory. While there are likely other profitable uses of their inventory spaces, quantifying those would be subjective and beyond the scope of this project. Ordering costs are also difficult to approximate for NOSTRA. NOSTRA utilizes the Defense Logistics Agency Electronic Catalog (ECAT) to place frame orders. This online system includes multiple vendors that have pre-negotiated discounted prices that include transportation, distribution, and administrative prices (Defense Logistics Agency [DLA], n.d.). Because of this, there are no shipping costs for NOSTRA when placing frame orders. Also, the cost to place orders is fixed, in the short term, as ordering and receiving personnel are salaried. While these personnel could be put to use elsewhere, quantifying the time and corresponding opportunity cost of placing and receiving orders was beyond the scope of this project (thus acknowledging an implicit opportunity cost of placing orders). Finally, when using a just-in-time system, carrying only what is needed to support operations for a short time period is preferred to carrying potentially larger amounts of stock. Therefore, the researchers decided to use the two-bin Kanban system with its order quantity formula based on lead-time and daily demand plus the safety stock as derived by Professor Uday Apte (personal communication, October 28, 2018):

$$\text{order quantity} = (L * DD) + SS$$

where
L = average lead-time (days)
DD = average daily demand
SS = safety stock

Daily demand was calculated by analyzing weekly demand and dividing that number by five and rounding up, as NOSTRA produces frames five days a week and partial frames estimates would not make sense. This analysis indirectly accounts for federal holidays as the clinics that submit orders to NOSTRA operate on the same DoD holiday schedule as NOSTRA and thus generally do not submit orders during holiday periods. Lead-time data for individual frames was not available, but NOSTRA estimated that it varied from two to six days. The upper end of the estimate (i.e., the lead time of six days) was utilized to give conservative results. We recommend that NOSTRA obtain a more accurate estimate of the lead-time of individual frames so that they can be used to determine more appropriate order quantities.

The decision to categorize the frames using the ABC method was made after viewing Table 4 and seeing the natural break points in the data. There were 48 SKUs (9%) that made up 80% of demand. The next 166 SKUs (32%) contributed the next 19% of demand. And finally, the remaining 312 SKUs (59%) made up the last 1% of demand. This distribution of demand generally follows the Pareto principle, in that a small portion of SKUs accounted for a disproportionately large amount of demand. The group of frames that made up 80% of demand were put in category A and the next two groups were put into category B and C respectively. Figure 9 depicts the distribution of frames across categories A through C.

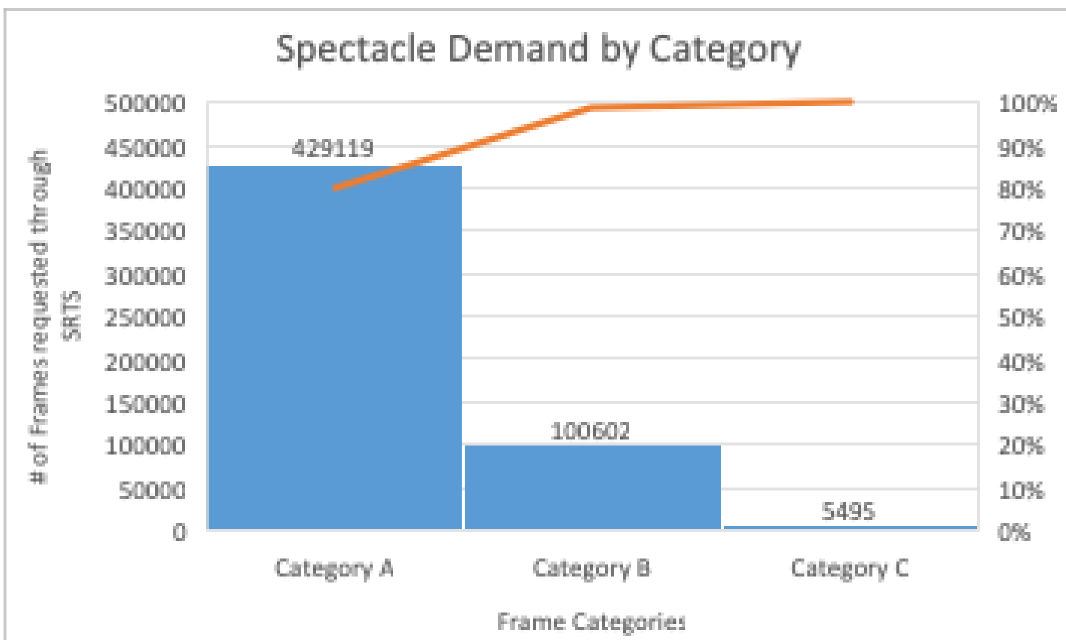

Figure 9. Spectacle Demand by Category

Table 4. List of SKUs Ranked by Demand in Descending Order

#	SKU (Style [Color and size])	Jan	Feb	…	Dec	Total	Percent of Total	Cumulative Percent	ABC Category
1	5A LARGE STANDARD FRAME [BLK, 52, 20, 145SKL]	4784	4658		4976	65855	12.30%	12.30%	A
2	REVISION UPLC INSERT [GRY, 42, 24, NONE]	2482	2765		2916	39367	7.36%	19.66%	A
3	M50 PMI [CRS, 54, 22, NONE]	1266	1739		3596	37066	6.93%	26.59%	A
4	5A LARGE STANDARD FRAME [BLK, 54, 20, 145SKL]	2053	2510		2474	29822	5.57%	32.16%	A
5	5A LARGE STANDARD FRAME [BLK, 50, 20, 145SKL]	1982	1964		1934	26463	4.94%	37.10%	A
…									
48	AIR FORCE FLIGHT FRAME [BLK, 55, 18, 140STB]	138	113		208	2394	0.45%	80.18%	A
49	ELITE 521 (FOC) [BLK, 50, 19, 145SKL]	234	175		173	2379	0.44%	80.62%	B
50	MASK COMPATIBLE (MCU2P - MAG 1) [BLK, 50, 22, NONE]	175	222		135	2373	0.44%	81.06%	B
51	KINGSVILLE 51 [BLK, 51, 17, 135SKL]	130	183		148	2317	0.43%	81.50%	B
52	5A LARGE STND FRAME W/NOSEPADS [BLK, 52, 22, 150SKL]	155	135		198	2282	0.43%	81.92%	B
53	5A LARGE STND FRAME W/NOSE PADS [BLK, 50, 22, 145SKL]	150	164		174	2250	0.42%	82.34%	B
…									
214	SIDE STREET (FOC) [BLK, 46, 19, 135SKL]	0	0		7	100	0.02%	98.98%	B
215	FLIGHT GOGGLE [GLD, 58, 20, 140STB]	16	4		10	98	0.02%	99.00%	C
216	5A MED STND FRAME W/NOSE PADS [BLK, 48, 20, 140SKL]	5	6		7	96	0.02%	99.01%	C
217	ELITE 521 (FOC) [BRN, 50, 19, 135SKL]	15	4		7	96	0.02%	99.03%	C
218	ELITE 521 (FOC) [BLK, 52, 21, 135SKL]	8	11		7	90	0.02%	99.05%	C
219	5A LARGE STANDARD FRAME [BLK, 54, 22, 140SKL]	17	6		7	87	0.02%	99.06%	C
…									
526	SIDE STREET (FOC) [BRN, 54, 21, 140SKL]	0	0		1	1	0.00%	100.00%	C
					Total	535215			

One advantage of using the ABC method is that different service levels can be applied to each category of stock. While this analysis constructed categorization based on demand, there are other practical methods such as cost of frame and even the spectacle prioritization system in Table 1. Frame cost was not used, as the frames offered in the DoD system are generally inexpensive. Categorization based on the spectacle prioritization system in Table 1 was very attractive, but difficult to implement because any frame could be a priority code 1. Also, while the standard frame is only in the priority code 1 category, many SKUs of standard frames had very low demand throughout the year; thus, focusing on these frames would not be the most efficient use of resources.

Figure 10 shows how variability in demand could affect the probability of a stock-out. If the slope of the line representing demand were to become steeper (demand increases), a stockout could occur. However, if the slope of the demand line were to become flatter (decreased demand), the organization could potentially hold excess inventory. With a 95% service level, the organization only has a 5% chance of completely exhausting on-hand inventory. Increasing the service level would necessarily increase the amount of stock held and the overlap between when one bin is full and the other is not yet depleted.

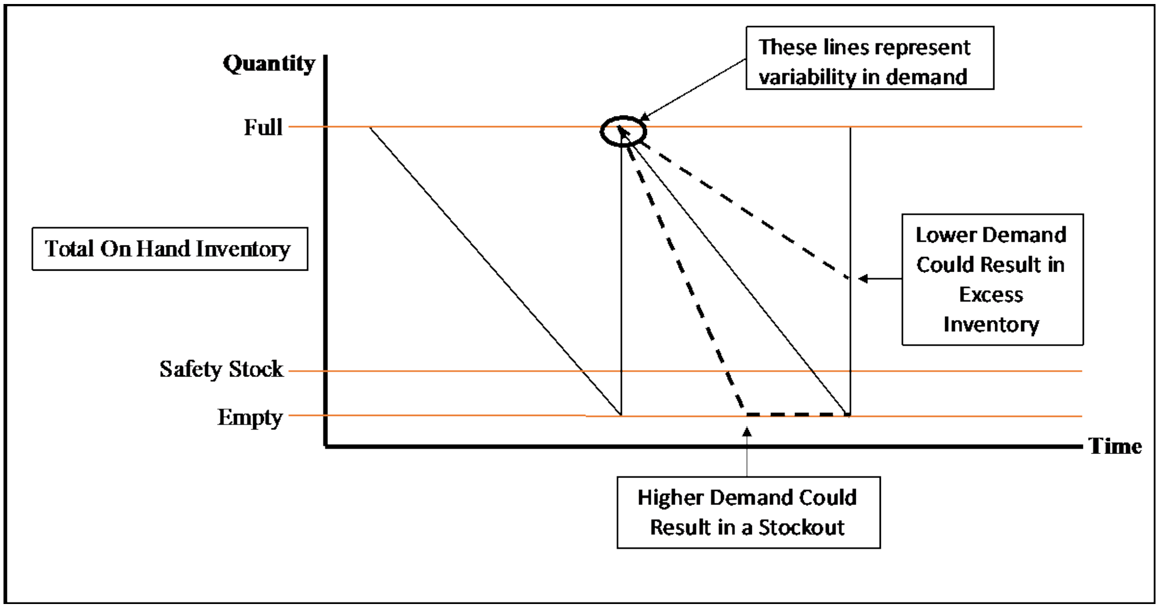

Figure 10. How Variability in Demand Affects Stock Outs

Considering the importance of safety stock in preventing stockouts, service levels were determined for each category. For this project, service levels were arbitrarily chosen to show what each service level would require in terms of total quantity of safety stock needed. This was done to aid NOSTRA in analyzing the trade-offs of service level and amount of inventory carried. Table 5 shows the service levels initially chosen for each category. As can be seen in Table 6, varying service level by ABC categorization results in lower levels of safety stock when compared to using a 99% or 95% service level for all inventory. Requiring a service level of 95% for every SKU necessitates holding 440 additional units of safety stock while having an overall 99% service level requires holding 2,408 extra units compared to using different service levels for each category of stock as shown in Table 5. Utilizing the ABC method allows organizations to have high levels of service for stock with the highest demand and lower levels of service for less popular products.

Table 5. Service Level Categorization

Category	Service Level
A	95%
B	90%
C	85%

Table 6. Amount of Safety Stock Needed at Given Service Levels

Service Level	Total Amount of Safety Stock Needed
Service Levels as per Table 5	5,781
99%	8,189
95%	6,221
90%	5,205

Table 7 shows the average daily demand, lead-time, safety stock, and finally the order quantity for a representative subset of the items. Average daily demand was calculated by dividing total annual demand by 260, the number of working days in 2017. Working days for NOSTRA typically are Monday through Friday, excluding national holidays. Average lead-time was derived from a rough estimate from NOSTRA staff. NOSTRA Staff believed it ranged from two to six days but in reality, it likely varies widely by SKU. The upper estimate of six days was used for all SKUs. An example of a safety stock calculation for the item number one in Table 7 is

$$\text{safety stock} = Z * \sigma_D * \sqrt{L}$$

where
Z = Z-score consistent with the desired service level
σ_D = standard deviation of daily demand
L = lead time (days)

Therefore, safety stock for item number one is 1.96 * 120.9 * $\sqrt{6}$ = 580.5. Order quantity was derived using the following formula:

$$\text{order quantity} = (L * DD) + SS$$

where
L = average lead time (days)
DD = average daily demand
SS = safety stock

Order quantity for item number one is derived by

$$(6 * 253.3) + 580.5 = 2100.$$

Using this analysis, each bin would contain an amount equal to the order quantity for that SKU. Once a bin was completely exhausted, an order would be placed for the order quantity. The safety stock would be the protection against stock out while waiting to receive the next delivery.

Table 7. Snapshot of Average Inventory, Order Quantity, and Safety Stock Levels

Category	#	Item Name	Avg Daily Demand (DD)	Standard Deviation of Demand	Lead Time (LT)	Safety Stock (SS)	Order Quantiy (DD*LT) + SS	Average Inventory
A	1	5A LARGE STANDARD FRAME,BLK,52,20,145SKL	253.3	120.9	6	580.5	2100	1631
A	2	REVISION UPLC INSERT,GRY,42,24,NONE	151.4	77.5	6	372.1	1281	1012
A	3	M50 PMI,CRS,54,22,NONE	142.6	68.2	6	327.3	1183	919
A	4	5A LARGE STANDARD FRAME 54 EYESIZE,BLK,54,20,145SKL	114.7	55.3	6	265.7	954	743
A	5	5A LARGE STANDARD FRAME,BLK,50,20,145SKL	101.8	49.3	6	236.6	847	660
	...							
A	48	AIR FORCE FLIGHT FRAME,BLK,55,18,140STB	9.2	7	6	33.8	89	78
B	49	ELITE 521 (FOC),BLK,50,19,145SKL	9.2	4.5	6	18.2	73	55
B	50	MASK COMPATIBLE (MCU2P - MAG 1),BLK,50,22,NONE	9.1	5.2	6	20.9	76	59
B	51	KINGSVILLE 51,BLK,51,17,135SKL	8.9	4.3	6	17.1	71	52
B	52	5A LARGE STND FRAME W/NOSEPADS 52 EYESZ,BLK,52,22,150SKL	8.8	5.2	6	20.9	74	58
B	53	5A LARGE STANDARD FRAME W/NOSE PADS,BLK,50,22,145SKL	8.7	4.9	6	19.5	71	55
	...							
B	214	SIDE STREET (FOC),BLK,46,19,135SKL	0.4	0.6	6	2.5	5	5
C	215	FLIGHT GOGGLE GOLD (HONOR GUARD ONLY),GLD,58,20,140STB	0.4	0.8	6	2.9	5	5
C	216	5A MED STANDARD FRAME W/NOSE PADS,BLK,48,20,140SKL	0.4	0.6	6	2.2	4	4
C	217	ELITE 521 (FOC),BRN,50,19,135SKL	0.4	0.5	6	1.7	4	4
C	218	ELITE 521 (52 EYESIZE)(FOC),BLK,52,21,135SKL	0.3	0.3	6	1.2	3	3
C	219	5A LARGE STANDARD FRAME 54 EYESIZE,BLK,54,22,140SKL	0.3	0.6	6	2	4	4
	...							
C	526	VISTA 520 (FOC),BRN,49,19,135SKL	0.02	0	6	0	1	0

Note. This table gives a snapshot of the inventory requirements. Service level is based on inventory categories, as shown in Table 5.

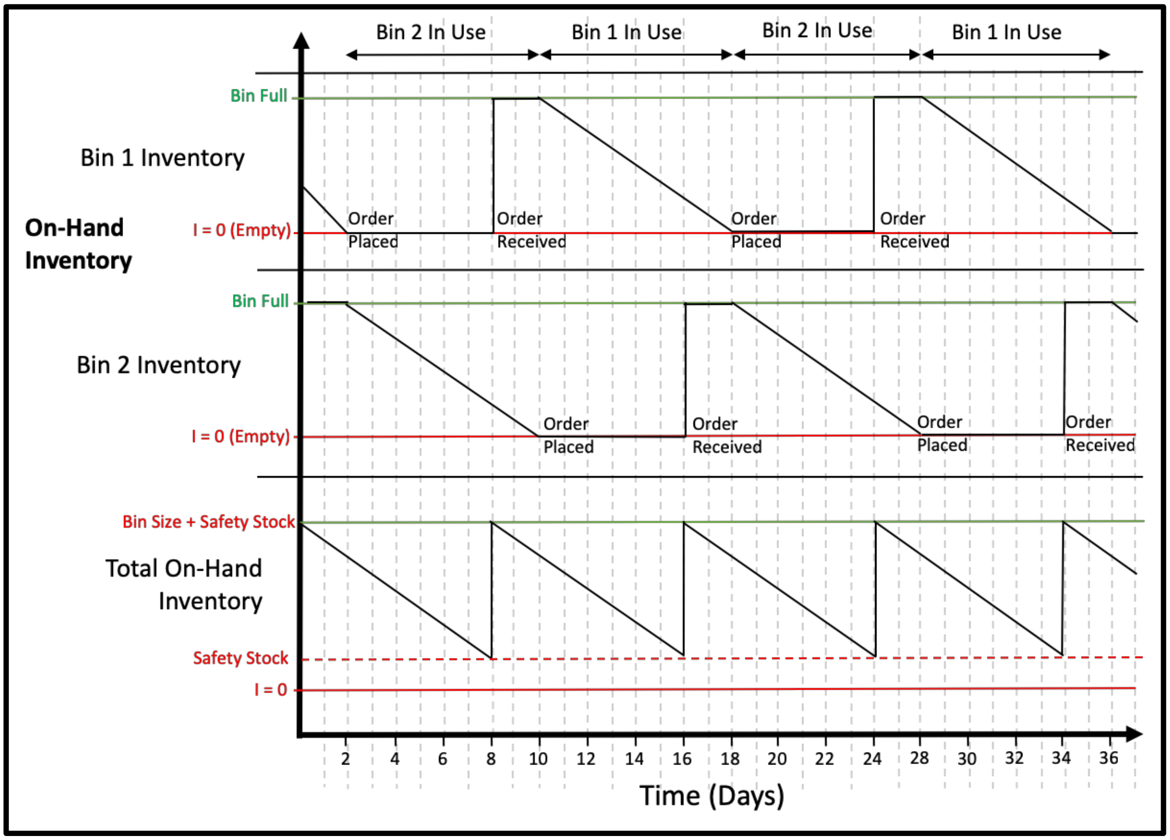

Figure 11. Two-Bin Kanban Inventory Diagram

The average inventory over the course of the process was also computed using the following formula derived by Professor Uday Apte (personal communication, October 28, 2018):

(quantity + safety stock)/2 + safety stock.

In Table 7, the average inventory for item number 1 was calculated by

(1519.7 + 580.5)/2 + 580.5 = 1631.

An overview of the inventory process over time is shown in Figure 11. This figure graphically shows the cycles that a bin would go through. In this example each bin contains approximately two days of safety stock. This is shown by the two day overlap between when one bin is replenished and the other is not yet depleted. The slope of the inventory curve represents the rate of demand. In this example demand and lead time stay constant throughout the entire cycle. However, in real life both of those variables would likely vary causing the need for safety stock. The variations of total on hand inventory can be seen in the graph as well. When demand and lead time are kept constant both bins will never be full or empty at the same time.

B. SUMMARY

This chapter began by discussing how the data was aggregated to analyze weekly and monthly demand. Next a rationale was given for choosing a periodic review system and the two-bin Kanban system, and how we calculated the bin size (order quantities) using the Kanban system. This decision was made based on the most feasible but efficient options considering NOSTRA's current system characteristics and its limitations.

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V. RECOMMENDATIONS AND CONCLUSION

A. RECOMMENDATIONS

The two-bin Kanban system has been successfully used in many industries, including healthcare and manufacturing. NOSTRA's mission to fabricate eyewear would make it a perfect candidate to implement a two-bin Kanban system. Some immediate benefits of implementing a two-bin Kanban system include the elimination of daily or weekly counting of supplies in inventory, ease in determining the ordering quantities and timelines, achieving the desired service levels, and finally, involving all staff in the supply process in a simple way.

While the two-bin Kanban system is a periodic review system, it removes the need to conduct daily or weekly counts of inventory. The visual nature of the system allows the inventory levels to be easily observed; the re-order signal is simply an empty bin. This system can free up manpower previously devoted to that task and decrease worry that an item will be depleted before the next inventory count takes place.

The two-bin Kanban system will likely require a higher frequency of orders than the current system. This is because the Kanban system seeks to decrease inventory and utilize a just-in-time process. Holding less inventory will ultimately be cheaper for two reasons; first, there should be less waste, and second, there is no additional cost of ordering when utilizing DoD procurement vehicles, because cost is fixed and there is no additional shipping cost when frames are ordered through ECAT. Also, there is an additional advantage to placing frequent and predictable orders. Placing orders on a more static schedule allows distributors to better plan their inventories and may allow them to properly forecast the stock needed to support NOSTRA. This could potentially decrease the number and duration of back-order items compared to when orders are erratic and for variable quantities.

Finally, this system involves the whole staff in the supply process. Because of its ease of use, everyone can participate. Once a bin is emptied, it could be standard procedure for the person who emptied it to take the bin (or card) and put it in a designated place to signal the need for replenishment. Due to the simplicity of the system, training requirements for staff would be minimal. Also, because staff understand the system, they would be less likely to hoard stock. Finally, when everyone is a part of the system, there would likely be more innovative ideas, as staff would have a baseline knowledge of the system and could more easily suggest incremental improvements.

B. IMPLEMENTATION

Principles of change management should be considered when implementing a new inventory management policy. The first steps would be to explain why the change is important, and then clearly describe to staff the benefits that will be achieved by changing the process and how those benefits will positively impact not only the mission but their roles within the organization. While undergoing the process improvement, important factors to consider are involving staff in the changes and soliciting their feedback. Having staff members who thoroughly understand the process and designing a systematic approach to implementation are also important. Once the process has been fully implemented, it will be important to show how the new process has improved the ability of the organization to meet its mission and also aided staff in completing their task. And finally, continuously reviewing the process will ensure that the organization is using the most appropriate and efficient inventory management systems for its operating environment. Other suggestions for implementation include the following:

- Start with a few items. Beginning with a handful of items will allow for testing of the system in a controlled environment. Items in the upper category B or lower category A would be the best, as these are not the most critical items and would still provide enough movement through the system to properly test it.

- Decrease lead-time. Considering the formula used to calculate order quantity, lead-time is the only variable that can be realistically influenced. Working with vendors to reduce lead-time would significantly reduce the amount of inventory needed for each bin. Also, shorter lead-times could increase the confidence of staff in using this system and allow the organization to better respond to changes in demand or demand variability.

- Use minimal or no special software initially in implementation. One of the biggest challenges with adopting a new system within the DoD is the requirement to use new software. If a new system is dependent on new software, it could be months or years before that software is approved for use. While software exists to support the 2-bin Kanban system, the system can be implemented without using that specialized software. The system recommended in this paper is designed to require low technology and is easily implemented.

C. LIMITATIONS

The principal limitation of this project is that it proposes an inventory system that we believe will work well at NOSTRA, but the project in and of itself does not evaluate its fit for NOSTRA. The primary reason for not evaluating fit is that a proper evaluation would require either studying the proposed system in operation for a period of time or collecting data that would allow for a simulation of the process. Given the scope of the project, implementing the solution and then studying it is far outside of the resources and time commitments available to the researchers. Regarding simulation, NOSTRA has at least three supply chain information systems with distinct purposes. Gathering and linking the necessary data from each system is also beyond the scope of this project. This project will suggest ideas to improve NOSTRA’s supply chain and provide future researchers with a starting point for designing studies to advance the same goal.

Another limitation is that this project only considered one year of data. While NOSTRA receives a significant number of orders each year, having multiple years of data would allow for further trend analysis. This is especially important because NOSTRA carries products that may be subject to fashion trends. Also, NOSTRA might carry sizes not ordered in the time period observed. Looking at demand and inventory patterns over multiple years would be preferred.

Finally, this project did not analyze lead-time variation. The lead-time this analysis used was approximations from supply staff rather than data from DMLSS. The main reason for this is that it is difficult to extract lead-time data from DMLSS for multiple items over a long time period. Having lead-time data is important, as lead-time has a direct effect on the amount of stock carried. It is also likely that lead-time varies significantly between products as well. Better lead-time information could be utilized to plan procurement strategies and replenishment timelines.

D. FUTURE WORK

NOSTRA has many features that could be studied in future projects. One initial area is conducting the same type of research for lenses. Developing a method to map demand data for lenses to lens SKUs would allow for analysis of that product. Testing potential inventory systems with simulation is also an area for future research. Finally, NOSTRA rotates frames in the FOC program regularly. Research into methods to plan for future demand for potential frames would be useful in inventory planning. This a problem that retail organizations have spent much time investigating and many techniques could potentially be applicable to NOSTRA.

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